

UTILITY APPLICATION

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UNITED STATES PATENT

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TITLED

BLEED VALVE SYSTEM

25

EL 621415265 US

Honeywell Docket No.: H0004409

Sheets of Drawings: Six (6)

Sheets of Written Description: Twenty-nine (29)

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BLEED VAVLE SYSTEM

FIELD OF THE INVENTION

[0001] The present invention relates to pressure control in gas turbine engines.

In particular the present invention relates to bleed valves for use at compressor stages

5 within gas turbine engines.

BACKGROUND OF THE INVENTION

[0002] Gas turbine engines such as those used in industrial, marine, vehicle,

and aerojet applications, may include multiple stages of compressors. In a typical

10 arrangement air is first drawn over a first compressor stage that elevates the air

pressure to a desired level. The air, while passing in a generally axial direction

through the engine, then crosses successive compressor stages that further raise the air

pressure.

[0003] It has been found that bleed valves can be used at various points on a

15 gas turbine engine to assist in maintaining a desired level of air pressure within the

engine. One area in a gas turbine engine where bleed valves are used is in the various

compressor stages. A bleed valve or series of valves may be used to control undesired

effects such as engine surge. Also it is desirable to provide pressure control during

certain dynamic engine conditions such as start up, acceleration, and deceleration.

20 And, in general bleed valves are beneficial for engine control.

[0004] Bleed valves are subject to a variety of stresses and pressures in the

engine environment. Debris and fouling present in the engine in particular may

adversely impact the moveable parts on a bleed valve. Moveable parts that include

carbon sealing rings, springs, pistons, and piston support shafts are thus subject to wear during normal engine operation. In order to increase the durability and reliability of bleed valves, it would be desirable to provide a bleed valve design that protects moveable parts from adverse conditions such as debris and fouling.

5 [0005] Certain bleed valve designs also have a pressurized state as their normal mode of operation. In this kind of design, for example, the bleed valve is closed when the engine is in a normal running state. However, to achieve the closed position, the bleed valve in that design must be pressurized through some supply of a pressurizing fluid. Thus this kind of design may be called the "Pressurized Closed" 10 design. When the bleed valve is to be opened, the pressurizing fluid is relieved, and the valve is allowed to open. The weakness in the "Pressurized Closed" design is the fact that the valve must endure the effects of pressurizing during the majority of the time the engine is in operation. Pressurizing subjects valve components to stress, and can thus hasten valve breakdown. Seals and rings, for example, tend to lose 15 effectiveness after experiencing prolonged periods of pressurization. Hence, it would be desirable to provide a bleed valve design that permits a bleed valve to be in the closed position during normal engine conditions but without the need to pressurize the valve to reach the closed position.

20 [0006] The harsh operating environment in the contemporary gas turbine engine also places increased stress on engine components such as bleed valves. In an attempt to increase the efficiencies and performance of contemporary gas turbine engines, engineers have progressively pushed the engine environment to more extreme operating conditions. The higher pressures that are now frequently specified

specifically place increased demands on bleed valves. Thus in current jet engine design there is also a need for a bleed valve design that is robust and reliable.

5 [0007] Certain bleed valve designs are known; nevertheless, there is need for an improved design. Hence there is a need for a new bleed valve design that addresses one or more of the above-noted drawbacks. Namely, a bleed valve design is needed that will protect moveable parts from debris and fouling, and/or that permits the bleed valve to be in the closed/nonpressurized position during normal engine conditions, and/or that provides a robust and reliable design. The present invention addresses one or more of these needs.

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SUMMARY OF THE INVENTION

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[0008] The present invention provides a bleed valve system. The bleed valve incorporates a housing and poppet that acts to protect moveable parts of the bleed valve from the debris and fouling encountered during engine operation. Parts of the bleed valve that are thus shielded include springs, shafts, wear surfaces, and sealing points. Additionally, the bleed valve system is designed so that it is in the closed/unpressurized state during periods of normal engine operation. The bleed valve design thus operates with minimal wear, stress, and fouling. Further the design provides a strong and reliable structure.

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[0009] In one embodiment, and by way of example only, a bleed valve design is provided. The bleed valve is designed for use in a gas turbine engine and includes a housing with an inlet and an outlet, the housing is generally hollow with an inner and outer surface, the housing further defines an interior region and an exterior region; a shaft guide is fixed to the interior surface of said housing; a shaft is mounted in the

shaft guide in a manner permitting the shaft to slide back and forth in the shaft guide; a poppet is attached to the shaft, the poppet having a seat to contact the a corresponding seat on the interior surface of the housing; a stationary piston is positioned in the interior region of the housing such that the stationary piston is in 5 contact with the poppet whereby the stationary piston and the poppet define a fluid chamber; sealing rings may be located between the poppet and stationary piston; a biasing means such as a spring is positioned in the interior of this chamber; and a fluid inlet provides fluid communication between the chamber and the exterior region of the housing.

10 [0010] In another exemplary embodiment there is provided a bleed valve located at an intermediate compressor stage of a gas turbine engine for use to relieve compressor pressure in the engine wherein this bleed valve may move between an open and a closed position. The bleed valve includes a housing having an inlet exposed to compressor air and an outlet exposed to fan air; a shaft and shaft guide; a stationary piston; and a poppet that is moveably attached to the shaft. The poppet has 15 a range of motion between an open and a closed position. When closed a face on the poppet engages a face on the housing so that air flow through the housing is restricted. Together the poppet and stationary piston define a chamber; optionally a carbon piston ring may be positioned between the poppet and stationary piston to promote a pressure seal in the chamber. A spring is positioned within the chamber that holds the 20 poppet in an open position when the gas turbine engine is off but that permits the poppet to move to the closed position when the engine compressor provides pressurized air to flow over the poppet.

[0011] In yet another exemplary embodiment there is provided a high pressure bleed valve for use in a gas turbine engine. The high pressure bleed valve includes a housing with an inlet and an outlet, the housing is generally hollow with an inner and outer surface, the housing further defines an interior region and an exterior region; a shaft guide is fixed to the interior surface of said housing; a shaft is mounted in the shaft guide in a manner permitting the shaft to slide back and forth in the shaft guide; a poppet is attached to the shaft, the poppet having a seat to contact the a corresponding seat on the interior surface of the housing; a stationary piston is positioned in the interior region of the housing such that the stationary piston is in contact with the poppet whereby the stationary piston and the poppet define a fluid chamber; sealing rings may be located between the poppet and stationary piston; a biasing means such as a spring is positioned in the interior of this chamber; and a fluid inlet provides fluid communication between the chamber and the exterior region of the housing. The high pressure bleed valve also includes a secondary chamber that is vented by a vent providing fluid communication between the secondary chamber and the exterior of the housing. The secondary chamber is positioned to move within a cylinder. The secondary chamber and cylinder optionally are in contact by a sealing ring to provide a pressurized seal within the secondary chamber. Optionally the vent is open to the fan air surrounding the compressor stage where the bleed valve is located. Optionally the secondary chamber and vent are part of a cap structure.

[0012] In another exemplary embodiment, there is provided a high pressure bleed valve as described above. The bleed valve is located at a compressor stage of the engine, for example a high pressure compressor stage, such that the fluid pressure

applied to the fluid inlet is taken from the compressor stage where the bleed valve is located.

5 [0013] Other independent features and advantages of the bleed valve system will become apparent from the following detailed description, taken in conjunction with the accompanying drawings which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 is a perspective view of an intermediate pressure bleed valve according to one embodiment of the present invention.

10 [0015] FIG. 2 is a cut away side view of the intermediate pressure bleed valve in the open position.

[0016] FIG. 3 is a cut away side view of the intermediate pressure bleed valve in the closed position.

15 [0017] FIG. 4 is a perspective view of a high pressure bleed valve according to one embodiment of the present invention.

[0018] FIG. 5 is a cut away side view of the high pressure bleed valve in the open position.

[0019] FIG. 6 is a cut away side view of the high pressure bleed valve in the closed position.

20 **DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT**

[0020] Reference will now be made in detail to exemplary embodiments of the invention, examples of which are illustrated in the accompanying drawings.

Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

[0021] Referring now to Figure 1 there is shown a schematic view of an intermediate pressure bleed valve. Bleed valve **10** includes main housing **20** defining an interior region and an exterior area. As is known in the art, main housing **20** may have on its exterior means to affix the bleed valve to the engine body. Flanged bolt holes with through bolts is one method by which the bleed valve may be attached to the engine. Main housing **20** may be a unitary or multi-component piece. For ease of manufacturing a multi component housing is preferred. Generally, the interior region of main housing **20** allows air to pass from opening **22** of main housing **20** through the interior region and passing out of outlet **24**, when the valve is in the open position. When closed, the valve restricts the passage of air through the main housing.

[0022] Referring now to FIG. 2 there is shown a cut away side view of a preferred embodiment of an intermediate pressure bleed valve. Disposed within the interior region of main housing **20** are other elements of the bleed valve, including stationary piston **60**, poppet **80**, shaft **70**, shaft guide **50**, support element **30**, spring **90** and fluid inlet **40**.

[0023] Still referring to FIG. 2 in a preferred embodiment, support element **30** is attached to main housing **20** and provides the structure that attaches to stationary piston **60** and/or shaft guide **50**. Support element **30** may be a single or multiple piece, meaning there may be more than one support element **30**. Figure 2 illustrates one support element; preferably, however, three support elements **30** are used. In an embodiment with more than one support element **30** each support element is

preferably radially spaced along the interior surface of main housing. Although equal spacing of the support elements is not necessary, it is preferred. Thus, in the embodiment with three support elements, each is equally radially spaced from the others. Support elements **30** do allow passage of air around them when air passes through the interior of main housing **20**.

5 [0024] Support element **30** illustrated in Figure 2 further includes fluid inlet **40**. Fluid inlet **40** is a passage that provides fluid communication from the exterior of main housing **20** with a point in its interior region. While it is preferred (to reduce mass and obstructions) that fluid inlet **40** passes through support element **30**, these 10 may be separate structures.

15 [0025] Still referring to Figure 2 and proceeding to the structure held by support element **30**, support element **30** is attached to shaft guide **50** and/or stationary piston **60**. Shaft guide **50** and stationary piston **60** are, preferably, separate structures. However alternatively, shaft guide **50** and stationary piston **60** are a unitary structure. Thus, it is stated that support element **30** is attached to shaft guide **50** and/or 20 stationary piston **60** to include the alternative where shaft guide **50** and stationary piston **60** are a unitary structure. Further, it is possible in one embodiment for support element to attach to stationary piston **60** rather than shaft guide **50**.

25 [0026] Shaft guide **50** is generally a hollow cylinder in shape. Shaft **70** is disposed within shaft guide **50**, but shaft **70** is allowed to slide within shaft guide **50**. Channels **160** may be included within shaft guide **50** and/or stationary piston **60** to provide fluid communication between fluid inlet **40** and fluid chamber **100**.

[0027] At one end, shaft **70** is attached to poppet **80**. Spring **90** is disposed around shaft **70** and shaft guide **50** in fluid chamber **100**. Fluid chamber **100** is the region defined by poppet **80** and stationary piston **60**. Shaft **70** may be attached to poppet **80** by conventional means such as a press fitting or a retaining nut.

5 [0028] In a preferred embodiment, shaft **70** includes flats. Flats contact the interior surface of shaft guide **50** thereby providing a uniform and smooth movement for shaft **70** throughout the stroke of shaft **70**. The number of flats provided may be one or more, preferably two or more flats are used.

10 [0029] Stationary piston **60** includes sealing ring **110**. In order to operate well at the pressures and temperatures encountered in the engine environment, sealing ring **110** is preferably a carbon piston ring. Other kinds of rings or sealing materials may be used as sealing ring **110**. While it is preferred that sealing ring **110** is attached to stationary piston **60**, in an alternative embodiment, sealing ring **110** is attached to poppet **80**.

15 [0030] Preferably stationary piston **60** and poppet **80** include surfaces on which a biasing means or spring may rest.

[0031] Stop **120** may be attached to main housing **20**. Preferably, poppet **80** touches stop **120** at resting point **130**. Thus resting point **130** limits the travel permitted to poppet **80**. Bleed valve **10** may include one or more stops **120**.

20 However, stop **120** should generally allow air passage from inlet **22** through the interior region of main housing **20**.

[0032] Poppet **80** includes poppet seat **140**. Poppet seat **140** rests against a corresponding housing seat **150** that is attached to main housing **20**. When bleed

valve **10** is in the closed position, poppet seat **140** mates against housing seat **150** thus restricting the passage of air through the valve body.

5 [0033] Fluid chamber **100** defined by poppet **80** and stationary piston **60** receives pressure from a fluid such as air that is admitted by fluid inlet **40** and channels **160**. Poppet **80** is attached to shaft **70** in a manner that prevents or minimizes pressure loss from fluid chamber **100**. Further shaft guide **50** is capped at one end so as to prevent or minimize pressure loss from fluid chamber **100** through shaft guide **50** by cap **55**. Likewise stationary piston **60** is attached to shaft guide **50** so as to prevent or minimize pressure loss from fluid chamber **100**. Finally, sealing 10 ring **110** provides a firm contact between poppet **80** and stationary piston **60** while still allowing movement therebetween. The degree of contact provided by sealing ring **110** is such that pressure admitted to fluid chamber **100** will be sufficiently maintained within fluid chamber **100** by sealing ring **110** so as to allow fluid chamber pressure to provide movement to poppet **80**.

15 [0034] Having described the intermediate pressure bleed valve system from a structural standpoint, a method of using such an assembly in operation will now be described.

[0035] Under normal atmospheric conditions, such as when the engine is not running, spring **90** holds bleed valve **10** in the open position. That is spring **90** or 20 biasing means pushes against stationary piston **60** and poppet **80** holding poppet **80** against resting point **130** of stop **120**. Once the engine starts, compressor stages begin to pressurize air flowing through the engine. Inlet **22** of bleed valve **10** begins to experience pressurized air flow. This pressurized air impacts against poppet **80**. The

pressure on poppet **80** overcomes the force provided by spring **90** and drives poppet **80** to the closed position. When bleed valve **10** moves through its stroke from the open to the closed position, shaft **70** slides within shaft guide **50**. In the closed position poppet seat **140** rests against housing seat **150**. The closure of poppet seat **140** with housing seat **150** restricts air from flowing through the bleed valve body.

5 [0036] When it is desired that bleed valve **10** should open, a signal is sent to provide pressure to fluid inlet **40**. Preferably, pressure is supplied to fluid inlet **40** from a solenoid valve subject to computer control. Moreover the fluid that is used to provide fluid pressure is preferably pressurized air taken from a compressor stage at a 10 higher pressure than the compressor stage where the valve is located. Thus, for example, air taken from a high pressure compressor stage may be directed through fluid lines to fluid inlet **40** of bleed valve **10** located at an intermediate compressor stage. Once high pressure air is admitted to fluid inlet **40**, the high pressure air within fluid chamber **100** provides force adequate to overcome the intermediate air pressure 15 that is tending to close bleed valve **10**. So by overcoming the intermediate pressure, high pressure air pushes bleed valve to the open position.

10 [0037] The act of moving from the closed to the open position can be described in further detail. As pressurized fluid is admitted to fluid inlet **40** it runs through channels **160** to fluid chamber **100**. Within fluid chamber **100** the pressurized 20 air pushes against the interior surfaces of poppet **80** and stationary piston **60**. In reaction to this force, poppet **80** moves laterally. As poppet **80** moves, shaft **70** also moves within shaft guide **50**. If the pressure is sufficient and the pressure is maintained for a sufficient period of time, poppet **80** will move along the full length

of its stroke until poppet **80** hits resting point **130** of stop **120**. In certain operations, poppet **80** may only be pressurized for a momentary period of time so that, while beginning to move along its stroke from the closed to the open position, poppet **80** never reaches the completely open position. The movement of poppet **80** to the open 5 position also separates poppet seat **140** from housing seat **150**. This opens a passageway through the interior of main housing **20** so that air can freely pass from inlet **22**, through main housing **20**, and exit at outlet **24**.

[0038] When, during engine operation, it is desired to close bleed valve **10** from the open position, pressure at fluid inlet **40** is removed. Again, this is preferably 10 achieved by solenoid valve under computer control. Thereupon the pressure within fluid chamber **100** is abated. Preferably the air pressure may be released from fluid chamber **100** by passing through fluid inlet **40** (in a reverse direction from when entering the bleed valve) to a release vent that is not shown. The air pressure force acting on poppet **80** again moves the poppet to the closed position. And at the closed 15 position poppet seat **140** makes contact with housing seat **150** thus restricting air flow through the interior of main housing **20**.

[0039] A further embodiment of the present invention is particularly directed to use at high pressure compressor stages. High pressure bleed valves present a unique challenge not encountered with an intermediate pressure bleed valve. At the 20 intermediate compressor stage, pressure to activate the bleed valve can be obtained from a compressor stage with a higher pressure than that at the intermediate compressor stage. Thus, as described above, the high pressure air will offset the intermediate pressure air, allowing the bleed valve to open. However, at the high

pressure stage, there is no source of still higher pressure air with which to overcome the pressure of that stage. The high pressure bleed valve described herein overcomes this problem by providing a secondary chamber.

[0040] Referring now to FIG. 4 there is shown a perspective view of a high pressure type bleed valve. The design of the high pressure bleed valve embodiment is generally similar to the intermediate bleed valve design, but does include certain differences. The high pressure bleed valve includes a main housing **20** defining an interior region and an exterior area. Main housing **20** allows air to pass from opening **22** through its interior to an outlet **24**. A high pressure bleed valves also includes elements in the intermediate pressure bleed valve such as poppet **80**, stationary piston **60**, shaft **70**, shaft guide **50**, support element **30** spring **90** fluid inlet **40** sealing ring **110**, poppet seat **140**, housing seat **150**, channels **160**, and cap **55**.

[0041] Referring now to FIG. 4 and 5, cut away views, high pressure bleed valve **200** also includes secondary chamber **210**, cylinder **220**, vent **230**, and secondary sealing ring **240**. FIG. 5 shows the high pressure bleed valve in the open position, and FIG. 6 shows the high pressure bleed valve in the closed position.

[0042] Still referring to FIGs. 5 and 6, secondary chamber **210** extends in a generally lateral position from fluid chamber **100** toward the main housing inlet **22**. Secondary chamber **210** is generally defined by wall **212** extending from the body of poppet **80** together with cap structure **235**. In a preferred embodiment, wall **212** that defines secondary chamber **210** is formed as a unitary piece with poppet **80** although other configurations, such as wall **212** being a separate piece, are possible.

[0043] Fluid in secondary chamber **210** is vented to a position outside main housing **20** through vent **230**. Further, secondary sealing ring **240** provides a contact between secondary chamber **210** and cylinder **220**. In a preferred embodiment secondary sealing ring **240** is in contact with cylinder **220** both when the valve is in its 5 fully open and fully closed position. This contact, together with the opening through vent **230**, maintains the pressure within secondary chamber generally at the air pressure that is present where vent **230** exits main housing **20**. Preferably, this air pressure is lower than the air pressure at main housing inlet. Preferably, this is vented to the fan area in an aerojet engine.

10 [0044] In a preferred embodiment the high pressure bleed valve includes a plurality of vents **230** such as three or four in number. In one embodiment, vents **230** are passageways defined in a cap structure **235**. One embodiment of such a cap structure **235** is shown in FIG. 4. Cap structure **235** generally provides a structure to which both vents **230** and cylinder **220** are attached. Preferably, cap structure **235** is a 15 unitary body with vents **230** and cylinder **220**. Cap structure **235** further defines arms **236** wherein are located vents **230**. Spaces between arms **236** define passages to allow air to travel from inlet **22** into the body of the bleed valve. Preferably arms **236** further provide a surface whereby to attach cap structure **235** to the body of main housing **20**. It is also to be noted that cap structure **235**, together with cylinder **220**, 20 act to isolate the pressure in secondary chamber **210** from the air pressure at inlet **22**, when secondary sealing ring **240** is in contact with cylinder **220**.

[0045] As with the intermediate pressure bleed valve, the high pressure bleed valve is free to move along a stroke between an open and a closed position. At the

fully open position, shown in FIG. 5, it is preferred that cylinder landing **222** contacts a surface of poppet **80**. Cylinder landing **222** is a receiving surface formed on cylinder **220** in order to receive contact with the surface of poppet **80**. It is this contact that establishes the fully open position for the bleed valve. This contact 5 defines the outer movement of poppet to the open position. Optionally the surface of poppet **80** can include a receiving surface to match with cylinder landing **222**. As with the intermediate pressure embodiment, when bleed valve is in the fully closed position, shown in FIG. 6, poppet seat **140** contacts housing seat **150**, thereby restricting fluid passage through the body of main housing **20**.

10 [0046] The high pressure bleed valve design operates with what is sometimes referred to as a “half area” actuator. (In the present invention the term “half” has no exact mathematical or relational significance; it is descriptive only of the type of design.) This method of operation relates to the fact that the air pressure at main housing inlet **22** is approximately the same as the air pressure at fluid inlet **40**.

15 However, air pressure to fluid chamber **100** provides enough force to open the valve because secondary chamber **210**, is in fluid communication with atmosphere outside the bleed valve. Preferably, the boundary walls of secondary chamber **210** are conical, polygonal, angled, or curved in shape. This shape defines a series of cross sections. The area of a cross section taken from secondary chamber **210** increases as 20 the cross section moves progresses from a point beginning adjacent to poppet **80** to a point at sealing ring **240**. This is illustrated as cross sections beginning with point A and moving to point B in FIG. 6.

[0047] In the previous paragraph the air pressures at main housing **20** inlet and at fluid inlet **40** are stated to be “approximately” the same for the following reason. In a preferred embodiment, the air that is provided to fluid inlet **40** is air that is drawn from the same compressor stage where the bleed valve is positioned. Thus, these 5 fluids should be at approximately the same pressures although in a precisely quantified measure, the pressures may fluctuate and be different. This is because in a dynamic engine environment, there may be relatively small pressure differentials between specific locations in a single compressor when measured at specific times. Thus fluid inlet pressure may actually be slightly different from the pressure acting at 10 the bleed valve inlet, and yet these two pressures can be said to be approximately the same.

[0048] In operation a high pressure bleed valve operates similarly to the intermediate pressure bleed valve. With the engine off and at normal atmospheric conditions, a high pressure bleed valve is in the open position. Spring **90** pushes 15 against stationary piston **60** and poppet **80** so as to hold poppet **80** in contact with cylinder landing **222**. When the engine starts and the engine compressor begins to pressurize air flowing through the engine, air pressure at inlet **22** acts against poppet **80** so as to push poppet **80** through the length of its stroke to the closed position, where poppet seat **140** rests against housing seat **150**. Air pressure admitted to fluid 20 inlet **40**, preferably air taken from the same pressure level as that at inlet **22** of a high pressure bleed valve, passes through channels **160** into fluid chamber **100** thereby pushing poppet **80** from the closed position, through its stroke, to the open position. During movement from the closed to the open position, air in secondary chamber **210**

exits through vent **250**. If the pressure remains applied, the movement of poppet **80** continues until poppet surface contacts cylinder landing **222**. Preferably pressure is controlled through a solenoid valve.

[0049] When pressure admitted to chamber **100** is abated, the bleed valve
5 returns to the closed position. Compressor air passing through inlet **22** impinging on poppet **80** forces it to the closed position. The movement to the closed position also moves secondary chamber **210** within cylinder **220** such that the volume of secondary chamber **210** increases. No vacuum resistance is encountered to this movement, however, because secondary chamber **210** is vented to a point outside the valve body
10 through vent **230**.

[0050] A first advantage of the disclosed bleed valve system is the operation of the bleed valve in a closed position without the need for pressure in the valve. Normal engine operation under normally expected conditions constitutes the majority of engine running time. It is during these normal conditions that the bleed valve
15 should be in the closed position. The function of a bleed valve, to siphon off excess pressure, is only needed during moments of engine operation. Thus, the present design provides an advantage of reaching the closed position without the need for pressure to be applied to the valve. This minimizes stress and wear on a valve arising from pressurized operation. In particular the sealing rings do not encounter the stress
20 of pressurized operation while the valve is closed under this design.

[0051] A further advantage of the bleed valve design is that it avoids debris and contamination reaching moving parts of the valve. Two components of the bleed valve in particular benefit from protection, and those are sealing ring **110** and shaft

70. Note that chamber **100** formed by poppet **80** and stationary piston **60** in the design of both the intermediate and the high pressure bleed valve acts to isolate shaft **70** from the air passage that takes place when compressor air passes through bleed valve main housing **10**. Further the shaft guide cap and shaft guide **50** protect shaft **70** from engine air. This design therefore protects an important moving part of the bleed valve.

5 [0052] Still a further advantage of this method is the protection provided to sealing ring **110** from air borne contaminants. In the intermediate pressure bleed valve, sealing ring **110** is protected against exposure to engine air when bleed valve **10** is closed. When closed poppet seat **140** and housing seat **150** engage to prevent engine air from passing through main housing **20**. Thus sealing ring is not exposed to pressurized air when the valve is in the closed position. In the open position, air passes around the body of poppet **80** and on across stationary piston **60**. The position of sealing valve, with poppet **80** providing an outer protection and stationary piston **60** providing an inner protection, acts to protect sealing ring **110** from extensive air damage when open. Further, for the majority of time during engine operation, bleed valve **10** is expected to be closed.

10 [0053] Still an additional advantage is the low pressure loss associated with the valve design. The valve housing presents a streamlined path for air passing through the valve body. The streamlined path helps minimize pressure loss in bleed air passing through the valve. This is true of both the intermediate pressure design and the high pressure design.

[0054] The contact of poppet seat 140 with housing seat 150 has been described as restricting air flow through the interior of main housing 20. Those skilled in the art will understand that the air flow is significantly restricted so that the desired pressure control or engine control is achieved. Thus a small or minute amount 5 of air may pass through bleed valve 10 even when in the closed position. For example, small surface irregularities on poppet seat 140 and housing seat 150 may permit a small amount of air flow. Nevertheless this small fluid flow is not so great as to defeat the bleed valve function of substantially restricting air flow in the closed position.

10 [0055] The terms high pressure and intermediate pressure have been used in discussing the bleed valve embodiments disclosed herein. While the terms intermediate pressure and high pressure do have relative significance in that, in a preferred embodiment, the high pressure valve operates at a compressor stage with higher pressure than that of the intermediate pressure bleed valve (when both valves 15 are used together in the same engine), the terms do not have a specific or quantified meaning. Thus the valves may operate in a multitude of gas turbine engines over a range of specific pressures provided they are used in the relative position described herein. Additionally, an intermediate pressure bleed valve may be used at any position in an engine compressor, provided there is a higher pressure compressor 20 stage from which to feed air into fluid inlet 40 of an intermediate pressure bleed valve. Further, a high pressure bleed valve could be used at any position on an engine compressor where the pressure into fluid inlet 40 of a high pressure bleed valve is approximately the same pressure as that entering inlet 22 of main housing 20. In a

preferred embodiment, both the intermediate pressure design and the high pressure design are used together in the same engine with the intermediate pressure bleed valve placed at a compressor stage of generally intermediate pressure and with the high pressure bleed valve placed at a compressor stage with pressure higher than that of the 5 compressor where the intermediate pressure bleed valve is located.

[0056] The materials that are used to construct the bleed valve designs described herein are those materials suitable for use in gas turbine engines, and especially including those materials suitable for aerojet turbine engines. Preferred materials include Inconel alloys.

10 **[0057]** While the invention has been described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt to a particular situation or material to the teachings of the invention without 15 departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.